



**UNIVERSITI PUTRA MALAYSIA**

**DESIGN AND PERFORMANCE ANALYSIS OF A NOVEL SWITCHED  
FITH ACCESS NETWORK**

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**DESIGN AND PERFORMANCE ANALYSIS OF A NOVEL SWITCHED  
FTTH ACCESS NETWORK**

**By**

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**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
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of the requirements for the degree of Master of Science

**DESIGN AND PERFORMANCE ANALYSIS OF A NOVEL SWITCHED  
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**Chairman: Elok Robert Tee, Ph.D.**

**Faculty: Computer Science and Information Technology**

Over these years, rapid development of bandwidth consuming applications has pushed the existing network infrastructure to the limit particularly in the access layer. There has been many development of high speed protocols to meet the demands but the existing physical medium, which consists of copper-based network, do not have the capabilities to support these protocols. Thus, the problem still exist and as time goes by, more and more demand and the use of high bandwidth applications have really clogged the access line. This problem is referred to as the access network bottleneck problem.

In addressing the access network bottleneck problem, Fiber-To-The-Home (FTTH) technology has been introduced in the local loop, taking advantage of optical fibers huge bandwidth. However, there is still one obstacle, which has been generally overlooked, which is, providing protection to the access line. The fiber optics access mainly consists of a single fiber running upstream and a single fiber running downstream. If a protection path were to be created, the network provider would have to



lay another 2 fibers on the network. This would increase deployment costs and also costs for the subscribers. Thus, a new way of providing fault tolerance to the system has to be introduced, by taking costs consideration and also efficiency in deploying the solution.

In this thesis, a novel scheme for providing fault tolerance to the FTTH system is introduced. Also, various classes of traffic are defined. All these classes of traffics can logically represent different applications based on their Quality of Service (QoS) requirements. These traffics are run on the switched FTTH access network model. The survival of the network is studied by terminating the supporting OLT unit one after another and observing the packet delay, packet loss ratio, the buffer occupancy and also the throughput of the switch. Results show that for different traffic classes, the number of supportable ONUs can exceed the standard value of the FSAN recommendations, which are 32 units per OLT. For example, for a two OLT access network, the maximum recommended supportable ONU units are 64 units whereas in the proposed system, up to a maximum of 128 ONU units can be supported under normal conditions; where there are no OLT failures or fiber breaks.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

**REKABENTUK DAN ANALISA PENEMUAN ASLI RANGKAIAN AKSES  
FTTH YANG MEMPUNYAI KEUPAYAAN BERSIUS**

Oleh

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Sejak kebelakangan ini, pembangunan aplikasi yang memerlukan banyak keperluan rangkaian telah menyebabkan jaringan rangkaian infrastruktur yang sekian ada tidak dapat menampung keperluan sebanyak ini terutamanya di rangkaian jaringan akses. Memang tidak dinafikan bahawa banyak protokol-protokol yang bekelajuan tinggi telah direka khas untuk mengatasi masalah ini tetapi medium fizikal seperti kabel rangkaian, tidak dapat menyokong protokol-protokol ini. Dengan ini, masalah tersebut masih ada dan dari masa ke masa, perkembangan pesat aplikasi yang memerlukan banyak “bandwidth” akan mengakibatkan saluran rangkaian akses menjadi lebih sesak lagi.

Dalam menangani masalah ini, teknologi Fiber-To-The-Home (FTTH) telah diperkenalkan ke bahagian rangkaian akses. Gentian optik mempunyai kebolehan untuk membawa banyak maklumat. Dengan semua teknologi ini, masih terdapat satu masalah

yang sering dipandang remeh iaitu memberi perlindungan kepada saluran rangkaian utama yang membawa maklumat. Saluran rangkaian akses gentian optik terdiri daripada satu gentian optik yang membawa maklumat ke “upstream” dan satu lagi gentian optik yang membawa maklumat ke “downstream”. Jikalau ingin memberi perlindungan kepada saluran rangkaian gentian optik, 2 lagi gentian optic tambahan perlu diletakkan ke dalam rangkaian tersebut. Ini akan meningkatkan kos instalasi dan juga kos untuk menggunakan perkhidmatan tersebut juga akan naik. Oleh itu, satu cara baru untuk memberi perlindungan kepada rangkaian akses tersebut perlu diperkenalkan dengan memberi penekanan kepada kos dan juga efisiensi kaedah tersebut.

Di dalam tesis ini, satu penemuan asli kaedah memberi perlindungan kepada rangkaian FTTH telah diperkenalkan. Di samping itu, pelbagai jenis kelas trafik telah diperkenalkan. Kesemua jenis kelas trafik tersebut boleh mewakili pelbagai jenis aplikasi bergantung kepada servis quality (QoS) mereka. Trafik-trafik ini digunakan dalam simulasi rangkaian FTTH tersebut. Keupayaan tahanan rangkaian tersebut dianalisis dengan mensimulasikan kerosakan OLT-OLT dalam rangkaian tersebut. Parameter-parameter seperti kelambatan paket, nisbah kerosakan paket, bilangan paket yang menduduki bufer suis yang digunakan dan juga throughput suis tersebut. Dalam keputusan simulasi yang didapati, bilangan ONU yang dapat disokong oleh rangkaian tersebut adalah melebihi bilangan ONU yang direkomendasikan oleh FSAN, iaitu hanya 32 unit untuk satu OLT. Dengan menggunakan kaedah kami, dua OLT dapat menyokong sejumlah 128 unit ONU berbanding dengan 64 unit ONU oleh FSAN.

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*November 2002*

*Lau Peng Wah*



I certify that an Examination Committee met on 1<sup>st</sup> November 2002 to conduct the final examination of Lau Peng Wah on his Master of Science thesis entitled "Design and Performance Analysis of a Novel Switched FTTH Access Network" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. The Members of the Examination Committee are as follows:

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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or currently submitted for any other degree at UPM or other institutions.

  
LAUPENG WAH

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## **LIST OF ABBREVIATIONS**

<b>ABR</b>	Available Bit Rate
<b>ADSL</b>	Asymmetrical Digital Subscriber Line
<b>APON</b>	Asynchronous Transfer Mode Passive Optical Network
<b>AS</b>	Autonomous System
<b>ATM</b>	Asynchronous Transfer Mode
<b>BAF</b>	Broadband Access Facilities
<b>CBR</b>	Constant Bit Rate
<b>CDV</b>	Cell Delay Variation
<b>CNT</b>	Counter
<b>CO</b>	Central Office
<b>CPE</b>	Customer Premises Equipment
<b>CTD</b>	Cell Transfer Delay
<b>DLC</b>	Digital Loop Carrier
<b>DP</b>	Delay Priority
<b>EDD</b>	Earliest Due Date
<b>EDF</b>	Earliest Deadline First
<b>EFM</b>	Ethernet in the First Mile
<b>ETSI</b>	European Telecommunications Standards Institute
<b>FCFS</b>	First Come First Served
<b>FIFD</b>	First In First Dropped
<b>FIFO</b>	First In First Out

<b>FITL</b>	Fiber-In-The-Loop
<b>FSAN</b>	Full Service Access Network
<b>FTP</b>	File Transfer Protocol
<b>FTTB</b>	Fiber-To-The-Building
<b>FTTC</b>	Fiber-To-The-Curb
<b>FTTCab</b>	Fiber-To-The-Cabinet
<b>FTTH</b>	Fiber-To-The-Home
<b>HDTV</b>	High Definition Television
<b>HOL</b>	Head of Line
<b>HOL-PJ</b>	Head of Line with Priority Jumps
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IP</b>	Internet Protocol
<b>ITU</b>	International Telecommunications Union
<b>LIFD</b>	Last In First Dropped
<b>LP</b>	Loss Priority
<b>LW</b>	Loss_Weight
<b>MAC</b>	Medium Access Control
<b>MPEG</b>	Moving Picture Expert Group
<b>MPLS</b>	Multi Protocol Label Switching
<b>MTBF</b>	Mean Time Before Failure
<b>MTTR</b>	Mean Time To Repair
<b>MTU</b>	Maximum Transmission Unit
<b>MUX</b>	Multiplexer

<b>NMS</b>	Network Management System
<b>nrt-VBR</b>	non real time-Variable Bit Rate
<b>OCF</b>	Oldest Customer First
<b>OLT</b>	Optical Line Termination
<b>ONU</b>	Optical Network Unit
<b>ORU</b>	Optical Repeater Unit
<b>OSI</b>	Open System Interconnection
<b>PBS</b>	Partial Buffer Sharing
<b>PDU</b>	Protocol Data Unit
<b>PON</b>	Passive Optical Network
<b>POP</b>	Point-of-Presence
<b>POTS</b>	Plain Old Telephone Service
<b>PS</b>	Pushout Scheme
<b>QoS</b>	Quality of Service
<b>RACE</b>	Research and development for Advanced Communications in Europe
<b>rt-VBR</b>	real time-Variable Bit Rate
<b>SCM</b>	Sub-Carrier Modulation
<b>SCP</b>	Self Calibrating Pushout
<b>SDH</b>	Synchronous Digital Hierarchy
<b>SDK</b>	Software Development Kit
<b>SMTP</b>	Simple Mail Transfer Protocol
<b>S-PON</b>	Super Passive Optical Network



<b>STM</b>	Synchronous Transfer Mode
<b>STP</b>	Spanning Tree Protocol
<b>TDM</b>	Time Division Multiplexing
<b>TDMA</b>	Time Division Multiple Access
<b>TH</b>	Threshold
<b>TV</b>	Television
<b>UBR</b>	Unspecified Bit Rate
<b>UTP</b>	Unshielded Twisted Pair
<b>VBR</b>	Variable Bit Rate
<b>VoD</b>	Video-on-Demand
<b>WDM</b>	Wavelength Division Multiplexing
<b>WWW</b>	World Wide Web
<b>xDSL</b>	x-Digital Subscriber Line